Size and modality effects in Braille learning. Implications for the blind child from pre-reading sighted children.

Background. Beginning readers are typically introduced to enlarged print and the size of this print decreases as readers become more fluent. In comparison beginning blind readers are expected to learn standard-sized Braille from the outset because past research suggests letter knowledge cannot be transferred across different sizes of Braille.

Aims. The study aims to investigate whether learning Braille using an oversized pegboard, leads to faster, transferable, letter learning and whether performance is mediated by either tactile or visual learning.

Sample. Sixty-eight children participated in the study. All children were sighted pre-readers with no previous knowledge of Braille. The children came from two nursery schools with an average age of 47.8 months

Methods. Children were taught specific Braille letters using either an enlarged pegboard or standard Braille. Two other groups of children were taught using visually presented Braille characters in either an enlarged or standard-sized and a further control group mirrored the experience of blind children in receiving non-specific tactile training prior to being introduced to Braille. In all tactile conditions it was ensured that the children did not visually experience any Braille for the duration of the study.

Results. Results demonstrated that initially training children with large Braille tactually led to the best subsequent learning of standard Braille. Despite the fact that both initial visual and large tactual learning was significantly faster than learning standard Braille, when transferring letter knowledge to standard tactile Braille previous tactile experience with the large pegboard offered the most efficient route.

Conclusions. Braille letter knowledge can be transferred across size and modality particularly effectively with large tactile Braille. This has significant implications for the education of blind children.

Sighted children are rarely taught to read using standard-sized print. Typically they are introduced to reading through enlarged letters and words. The size of print decreases slowly over the learning process as reading improves. In contrast, blind children are expected to read standard-sized Braille from the outset rather than being introduced to Braille through enlarged characters. If sighted children can transfer their knowledge about letters from enlarged ones to standard-sized equivalents, it seems plausible to conjecture that blind children may benefit from a similar learning process.

There has been little work systematically investigating the size of the Braille cell and how this might affect the process of learning to read in young blind children. The traditional view of the use of an enlarged Braille cell for teaching young blind children is that it would not be helpful. The clearest statement of the potential problems comes from Millar (1977) who claims that blind children cannot transfer knowledge of the same spatial pattern across different sizes. In other words, if children first learned to recognise Braille letters though experience of an enlarged cell, they would not then be able to recognise the same letters in standard (smaller) Braille. Millar argues that this is because there is a problem at the level of coding that does not make for easy transference of information across two sizes of Braille. Part of the problem stems from the fact that a Braille cell is 'read' by the fingertip. A cell that is larger than the size of a fingertip cannot be processed in this way and so the concern is that an enlarged cell will not provide the same pattern of touch sensation as a standard cell. However, this latter concern ignores that possibility that initial exposure to an enlarged cell may provide something other than directly transferable sensation. For example, experience with an enlarged cell might allow blind children to discover the relative position and number of dots as well as some insight into the basic structure of the 2 x 3 Braille matrix.

In sum, Millar (1997) suggests that any letters learnt in an enlarged format would then need to be completely relearned in standard Braille. She points out that Braille readers who code letters by shape would not have this problem of transference but implies that instead young children tend to use dot-gap density as a form of letter coding. Giving the example of how clues as to the identity of a given letter often rely on small differences in the spaces between dots, Millar suggests that this might explain why changing the format of Braille might require re-learning. However simply changing the format of Braille would not alter the relative distances between individual dots within the cell, and might indeed assist the child in working out the shapes of each letter, thereby introducing an alternative coding strategy to the young child.

Studies of adult and adolescent readers suggest that a larger Braille cell can facilitate learning. Newman et al. (1982) and Newman, Kindsvater and Hall (1985) showed that sighted undergraduates learned Braille faster when an enlarged Braille cell was used in the learning condition even when a standard cell was used in the testing condition. Similarly, Tobin, Burton, Davies, and Guggenheim (1986) report that blindfolded sighted 13-15 year olds showed a slight learning improvement with Braille in an enlarged format while, as before, testing used solely the standard-sized cell. The view that an enlarged Braille call can facilitate learning is also reflected in Tobin's (1971) finding that 53% of teachers of adventitiously blind adults favoured learning Braille using the enlarged rather than standard cell.

Other evidence supports the view that an enlarged cell benefits learning to read Braille. For example, Harley, Pichert and Morrison (1985) studied blind and sighted diabetic participants who again showed a tendency to higher mean scores using an enlarged Braille cell in the learning condition. Heller and Mitchell (1985) found that large size Braille facilitated reading two-letter Braille words. Participants using standard Braille also showed a significant improvement when the spacing between letters was increased. This suggests that the effect was probably due to the increased spacing between letters that occurred with the larger Braille.

It is important to note that the term 'large' or jumbo' cell in these, and similar studies, refers to a cell where the spacing between dots is typically only increased by 34%, and the space between corresponding dot positions in adjacent cells is only 56% greater, the diameter of the base of the dots increasing by 12%, while the height of each dot remains the same (Tobin et al., 1986). This proportional increase in size is much smaller than that found in the enlarged print used with beginning sighted readers.

Whilst Millar has carried out seminal work in the field of cross-modal coding and Braille reading (see Millar, 1997 for a review), none of these studies looked at young pre-reading blind children who are just starting to learn to read. Typically these early studies used older children or children who could reliably name the test letters used in the research. The current research is unique in that as far as we know it is the first to look at a sample of pre-school, pre-readers. Using a pre-reading group learning letters for the first time aims to mirror more closely the experience of blind children when they come to the task of first learning Braille.

Of course learning to read involves not only decoding skills but also comprehension skills. Additionally learning Unified English Braille requires the learning of around 200 Braille contractions or short form words (symbols that represent groups of letters or even whole words) and the complex rules that govern their use. However, the initial step of learning letters has been shown to be a critical aspect of reading development. In a study motivated by research with sighted children that emphasised the importance of pre-school print experience in learning to read; Barlow-Brown & Connelly (2002) demonstrated the comparable importance of pre-school written (Braille) letter knowledge to phonological awareness in young blind children. Children in their study did not develop phonological awareness (a long established factor related to successful reading ability) until after they had developed written knowledge of individual letters of the alphabet. Representation of letters in a meaningful written format thus appeared to be as important for blind children learning to read as has been shown for sighted children. If the current study can demonstrate that an enlarged pegboard leads to faster letter learning and that those letters can be transferred to standard-sized Braille then this would have implications for teaching pre-school blind children letters in Braille to aid phonological awareness and subsequent reading development.

The first aim of the present study was to investigate the use of an enlarged Braille cell in the teaching of Braille to young novice readers and to compare progress in the learning of letters using standard and enlarged Braille. The study also aimed to determine the extent to which learning could be transferred from enlarged to standard Braille. The present study used a substantially bigger increase in size than previous studies and the Braille cell was 4.5 x 6.5 x 1.3 cm of clear plastic with 6 holes bored into the plastic for 6 small round pegs (diameter .5cm, length 1.5 cm each). This greatly enlarged cell allowed children to explore the individual dots of the cell.

The second aim of the study was to compare the learning of (tactile) Braille with the learning of visually presented Braille. Investigating the learning of visual Braille is theoretically important because it allows the distinction between difficulties in Braille learning that arise from the format of the Braille characters (i.e., dots in a 2 x 3 matrix rather than the lines, curves, dots etc., of print) and the difficulties that arise from use of the haptic rather than the visual modality. Typically, blind children take at least a year before they can recognise all the letters of the alphabet (Pring, 1994; Harris & Barlow-Brown, 1997) and it has been suggested that blind children do not reach a reading level comparable to their sighted peers until they are approximately twelve years of age (Lorimer, 1977). However, although it is clear that blind children are slower to learn Braille than their sighted peers are to master print, it remains to be determined whether the greater difficulty of Braille arises because it has to be learned by touch rather than sight or because the Braille characters themselves are more difficult to discriminate than printed letters.

As with the case of enlarged Braille, comparisons between haptic and visual presentation have been made with sighted undergraduate students. Newman and Hall (1987) found that participants learnt Braille significantly faster if they were taught visually even though testing was done in the haptic modality. These authors suggest that teaching participants to identify Braille characters by informing them of the number of dots each contains may also facilitate identification. In support of this view, in a previous study, Newman et al. (1985) found that participants were not able to report the correct number of dots that a cell contained after examining it in the haptic modality.

The evidence from adult studies suggests that both increasing the size of the Braille cell and using visual rather than haptic presentation facilitates learning. The present study explored the contribution of these two factors to the Braille learning of young, sighted, pre-reading children. The participants were pre-schoolers and hence had acquired little or no of print letters which might interfere with learning the letter names for Braille. Five different conditions were used, these were standard Braille and enlarged Braille (both presented as tactile stimuli), small and large visually presented Braille, and a non-specific tactile training condition to mirror the experience of pre-school blind children. There were two phases to the study. In the training phase, children were divided into five groups with each group being exposed only to one kind of training. Success in letter learning was monitored and compared across the first four groups. It was predicted that using a greatly enlarged Braille cell in the tactile condition would lead to faster learning of letters in comparison to standard Braille; and that learning Braille visually would be significantly easier than learning it tactually, but that there would not be an effect of Braille size in the visual conditions. This prediction was based on the contention that it is not an effect of size as such that is important in learning to read

Braille, but that knowledge of the spatial relations among dots will be made available both through an enlarged tactile cell and from visual presentation of the Braille cell.

Following the training phase, all children were presented with standard (tactile) Braille in a test phase. It was predicted that there would be transfer from the training phase to this learning/testing of standard-sized Braille such that children who had experienced the non-standard conditions would learn standard Braille faster than children who had not received any prior exposure. Documenting an ability in young children to transfer knowledge across different sizes of the Braille cell has important practical and theoretical implications. Such a demonstration would encourage the redesign of the teaching and learning experience of young blind children learning Braille and would also invite a reformulation of how these children represent Braille. Evidence of transfer from enlarged to standard Braille would also question Millar's (1977, 1997) claims that information regarding the shape of Braille letters is not coded by children since her findings suggest no transference of knowledge across size. If it could be shown that children can transfer such knowledge, it would mean that something not specific to the physical dimensions of the tactual stimulus itself is coded in memory.

Method

Design

This study took the form of a longitudinal training study over a period of 12 weeks. The study was split into two parts each lasting six weeks. The first was a training phase and the second a test phase.

The Training Phase

Participants were allocated to one of the following five conditions with an attempt to match IQ across conditions: (i) large tactile, learning large Braille letters tactually; (ii) small tactile, learning standard-sized Braille letters tactually; (iii) large visual, learning large Braille letters visually; (iv) small visual, learning standard-sized Braille letters visually; and (v) a control group that we have referred to as 'non-specific tactile', that is non-specific tactile training to mirror the pre-school experience of blind children. In all tactile conditions it was ensured that the children did not visually experience any Braille for the duration of the study.

In all a maximum of nine letters were taught during the training phase. The children were introduced to one letter at a time, and only when they had recognised this letter from an array of four 'distracters' on three consecutive trials, were they introduced to the next letter. Thus, each trial consisted of four distracters and the target letter. The position of the target letter among the distracters was counterbalanced across trials. The distracter items were made up of a combination of the following types of letters; a reversal of the target letter, that is, the same shape as the target but in a different orientation, a letter with the same number of dots as the target but forming a different shape, and a letter that was dissimilar to the target letter.

The nine Braille characters used during the training phase were taken from the RNIB Braille for infants reading scheme. They are the first nine Braille characters that blind children are taught, and they were taught in the order prescribed by the RNIB scheme. The letters were A B G L I C T H E.

The letters in Braille:

----- Insert Figure 1.0 ----

The Test Phase

The test phase began after the initial six weeks of training, and a one week 'half term' holiday. All children were introduced to standard-sized Braille tactually to see whether there had been any transference effect from the training period of the study. The children were taught the same Braille letters as used in the training phase, using exactly the procedure.

Participants

Seventy-four sighted children (mean age = 47.8 months) were selected from two Nursery schools solely on the grounds that they attended at least three times per week, and that they could not read. The children were given the short form of the British Ability Scales (BAS) IQ test. The children were allocated to one of five conditions so that IQ and age were counterbalanced across the conditions. However, of these initial seventy-four children, one left the nursery in the first week of testing to start infant school, one transferred to an alternative nursery, and four of the remaining sample (the youngest of the children) did not have the language capabilities to communicate with the experimenter and so had to be excluded from the sample. Sixty-eight children were thus allocated to one of the five conditions; large tactile (*N* = 15), small tactile (*N* = 16), large visual (*N* = 12), small visual (*N* = 11) and general tactile (*N* = 14).

Procedure

The Training Phase. The training sessions took place in a quiet room at the children's schools. Each child was visited three times a week, and was seen individually for 10 minutes each session. In the initial session, before being taught specific letters, the children were briefly asked to play a 'matching' game in which they were given a set of four Braille letters, three of which were identical and one of which was different. The letters were presented according to the condition the child had been allocated to, and they were asked to find the 'odd one out'. In both tactile and visual conditions the Braille letters were presented on the table in front of the child and the child had to feel/look at them without picking them up. This part of the procedure was the same when subsequently learning letters and when tested on them.

After being familiarised with the Braille cell through the matching game, the training procedure was started. Children were introduced to one letter at a time and only when they had learnt a particular letter successfully (defined as three consecutively correct identifications from an array of distracters in any one testing session) were they introduced to the next letter. No time limit was imposed on children exploring and learning each Braille letter. If a child incorrectly selected a specific letter or failed to recognise a specific letter then they were presented with the letter again and given its correct name. At each session the children were always asked to find the letters they had already learnt, in addition to being taught new ones if applicable. Their responses were recorded, including errors made, on each trial.

Part 2 - The Testing Phase. In this phase the children were seen on the same basis as before except that all letters were presented tactually in standard Braille. On the first session the children were given all the letters that they had previously learnt and were asked if they could think what letters they might be. Thus a record of whether there was any immediate transference from the previous conditions, without additional training or tuition, could be noted. On subsequent sessions the children were taught the Braille letters in standard Braille. This included teaching them new letters, and letters that they had previously been taught in the training stage of the study but had not been able to transfer to this testing phase. Those children in the standard Braille condition simply continued to learn letters as before.

Materials

A set of specially constructed plastic 'Braille bricks' was used in the training phase of the study for the large tactile condition. This ‘Braille brick’ (or pegboard) was 4.5 x 6.5 x 1.3 cm of clear plastic with 6 holes bored into the plastic for 6 small round pegs (diameter .5cm, length 1.5 cm each). Braille letters typed on strips of labelling tape and mounted on strips of card were used in the tactile standard Braille condition.

A set of coloured cards 10cm by 5cm, with enlarged Braille letter configurations printed in the centre were used in the large visual condition and similar cards with standard-sizedBraille letters printed on them were used in the small visual condition.

A plastic 'table' was made for use in the tactile conditions with cloth draped over the top of the table and the child’s arms. This allowed the children to place their hands under the table to explore the letters without seeing them, while still allowing the experimenter to see the child's hand and finger movements from the other side of the table.

In the testing phase all the children used stimuli in the form of the standard tactile Braille condition.

Results

The Training Phase

A score of the number of letters they had learnt to criterion was calculated for each participant.

---- Insert Table 1 ------

A one-way analysis of variance revealed significant differences between the conditions, *Welch’s F* (3, 22.78) = 19.14, $p < .0001$, *est* ω^2=.38. Planned comparisons showed that the large tactile condition led to greater letter knowledge than using standard Braille, $t(34.94) = 3.53$, $p < .001$. However, there were no significant differences between the large tactile and the large visual condition, $t(22.50) = -1.43$, $p > .05$, or, the large tactile and small visual condition, $t(21.36) = -.22$, $p > .05$. Comparisons demonstrated that regardless of modality, size did matter and large media led to better initial learning than the smaller media, $t(34.94) = 3.52$, $p < .01$. Also, visual conditions generally led to better initial learning than tactile conditions, $t(34.94) = 3.86$. $p < .001$.

The Testing Phase

The same scoring procedure as above was used to generate a score based on each child's performance when learning standard tactile Braille in the testing phase. This analysis includes the fifth (control group) condition 'general tactile training' where children are being taught letters for the first time using standard Braille. A one-way ANOVA revealed significant differences between groups in this testing phase, *Welch's F* (4, 26.20) = 22.66, $p < .0001$, *est* $\omega^2=.43$.

---- Insert Figure 2 -----

In this testing phase we examine the transference of knowledge from the learning phase, which used differing Braille letter media, to this testing phase where all participants used standard tactile. Planned comparisons showed that learning with the large tactile Braille led to significantly better performance when compared to all of the other conditions. Large tactile Braille compared to; standard Braille, $t(25.26) = 3.88$, $p< .001$; large visual $t(22.70) = 4.02$. $p< .001$; small visual $t(18.94) = 2.13$, $p < .05$; general tactile training $t(15.91) = 8.55$, $p < .001$.

Discussion

The key results demonstrate that the children using the large Braille cell tactually when learning Braille perform better than all the other groups when later learning standard Braille in the testing phase. This superiority existed regardless of the modality or size of the Braille used.

There are three key features of the data from the experiment reported here. First, the results demonstrate that learning Braille letters is easier (and faster) when they are presented visually rather than tactually. This substantiates previous findings in this field (e.g., Newman et al, 1982, 1985). Second, within the tactual modality, large Braille is significantly easier to learn than standard Braille. This is an important finding. It shows that it is not necessarily the spatial configurations of Braille letters that are hard to learn, but something more specific to standard-sized Braille. While this experiment has shown that it is easier to learn Braille letters visually than tactually, what is also important (particularly to the study of how blind children learn to read Braille) is the fact that large tactile Braille was significantly easier to learn than standard Braille.

Third, the importance of this is heightened by the finding that the letters learnt by children using large tactile Braille were transferred more effectively to standard-sized tactile Braille than any of the other conditions. Since it is easier to initially learn large Braille tactually than standard Braille, and given there is no problem transferring the knowledge acquired from the large cell to the standard cell, this would be a more efficient route into learning Braille letters. This finding should be of great importance for the education of the blind child. For the blind child learning the alphabet in Braille is a very slow and time-consuming process, any assistance in this process should be seized upon (Pring, 1994; Harris and Barlow-Brown, 1997).

These findings support our contention, outlined earlier, that that the types of training undergone by the participants in this experiment lead to an awareness of the spatial relations between individual dots in Braille letters. This would account for the finding that there was little difference between performance in the two visual conditions (large and small). This suggests then that it is not size as such that accounts for the findings, but something common to both visually learning Braille letters and tactually learning large Braille, that makes it easier to then learn standard Braille rather than learning standard Braille directly. Support for this notion can be found in Millar (1981) who stated that "Vision is neither necessary nor sufficient for spatial tasks. But it draws attention to external cues, and to directional connections between them which makes spatial coding easy" (p. 307). It may also be true that maintaining modalities is beneficial (and essential for the blind) but the child needs first to be able to gain the required information to establish an effective mental representation. The large tactile condition, which leads to our best future standard Braille ability, may simply offer a level of acuity not available to inexperienced hands searching for subtle differences in haptic information.

Hampson and Duffy (1984) clearly demonstrated that spatial relations can be learnt effectively through touch, and lead to equivalent representations in the blind as the sighted despite the fact that the sighted have gained their representations through vision. This might then be taken as support for the above argument, that the children in the present study were able to learn the spatial relations between dots in individual Braille letters through the use of the tactile pegboard, or through the visual medium, but were less able to do this in the standard-sized tactile Braille condition due to the restrictive physical nature of the stimuli.

These findings have theoretical and practical implications. If it can be established that learning large tactile Braille enhances the discriminability of standard Braille, and facilitates the subsequent learning of standard Braille, then this has important consequences for the teaching of blind children. This is particularly so when one considers that typically blind children are not introduced to Braille until the time that they start school at approximately five years. Since sighted children are exposed to a visible language from birth, they are already advantaged when it comes to starting school and embarking on the task of learning to read. Indeed the sighted child can already identify many letters on beginning school, which the blind child is unable to do. This lag in the early stages of learning to read is perhaps best demonstrated by the fact that it takes blind children over a year before they have been introduced to all the letters of the alphabet (Pring, 1992). Should the process of letter learning be speeded up, then perhaps so too could the process of learning to read. Literature has suggested that this early written (Braille) letter knowledge has significant implications for phonological awareness and subsequent reading development (Barlow-Brown & Connelly, 2002). It is then possible that the documented delays in Braille reading in blind children might be considerably reduced (Lorimer 1978; Pring, 1992, 1994).

It is traditionally argued that tactile sensory processing is not well developed in young blind children, and hence Braille is not introduced until after these children enter school. However if children were introduced to the Braille cell format using an enlarged pegboard, as utilised in this study, the under development of tactile sensory processing would have less of an effect. The results of this study would predict a transference effect from the larger peg board to standard Braille when the child was ready. In the past this has not been considered a viable option. Research by Millar (1977) suggests that blind children are unable to transfer information from a cell even marginally larger in size to the standard Braille cell. Teachers of the blind have considered that learning letters from a large pegboard is not using the same skills required for perceiving standard Braille letters tactually - that a pegboard encourages sequential exploration of the cell whereas standard Braille assumes simultaneous perception of the dot patterns of each letter. However the current study has shown that it is perfectly possible to transfer information directly from a small pegboard to standard Braille in sighted children. The question then arises as to the exact nature of the information that is being acquired from a large cell and transferred to the standard cell. One way of answering this question is to look at the results relating to training across the two different modalities. It is of theoretical interest to note that there was no significant difference between those children who had visual training and those trained using a large tactile cell, in terms of their subsequent performance learning standard Braille. Thus since visual experience is not significantly better than haptic experience it would suggest that the cause of delays in blind children's reading development, is not necessarily a problem of tactile coding as such and coding spatial information may not be tied to a specific modality. This argument about how spatial information is coded is not a new one. Controversy over the form that mental images take has long been of issue (Neisser & Kerr, 1973; Zimler & Keenan, 1983). While the majority of authors deny that they believe internal images to be 'mental pictures', some do claim that the images are based on the same properties from which visual perceptions are formed. The converse view is that internal representations are no more than a set of propositional arguments. In an attempt to ascertain whether these images are visually based or not, researchers have examined the congenitally blind. Kerr (1983) suggested that congenitally blind adults can handle spatial images comparably to sighted individuals. Kerr goes on to surmise that the ability to process spatial images is not modality specific. Zimler and Keenan (1983) similarly found similarities between blind and sighted adults and children on tasks presumed to involve visual imagery in memory - thus suggesting that vision is either not necessary for forming mental representations – or not used as such by the sighted. De Beni and Cornoldi (1988), in agreement with previous research, found that blind subjects used imagery as a device in memory. However, they found specific limitations with the blind subjects' imaginal processes, in that the blind appeared to have difficulty with multiple or composite images as opposed to the simple images used in previous research. One suggestion made by the authors was that the blind process information (be it tactile or auditory) serially, whereas the sighted using the visual system can take several pieces of information in, simultaneously.

Since vision is the primary code for sighted children, but mean scores were higher for those sighted children in the large tactile condition, one might expect that blind children would be better still, since haptic exploration is their primary method of coding. However, it may be premature to assume that the primary coding method of any population should have an effect in this manner. It could simply be the case that either route to coding spatial information may be used, regardless of how other types of information are coded by the blind and sighted. That it is simply a case of using whichever medium is available, and then a common internal code of that spatial information is formed. Thus, the results of the present experiment have demonstrated that it is not a problem of the stimulus itself that causes problems in coding, since it can be coded adequately both visually and with a large tactile cell. Similarly, as discussed above, it seems not to be a direct problem of tactile coding as such. If it is not a problem of the stimulus or a problem of tactile coding then it may simply be that the small size of the standard cell does not allow the same wealth of information to be drawn from it as any of the other methods described. Perhaps the visual system and the large tactile cell are giving the child an accurate and informative framework of the Braille cell on which to base subsequent information gained from feeling standard Braille. Whilst the study has attempted to provide a unique insight into factors affecting how pre-readers learn Braille; on its own it cannot address the possible theoretical explanations discussed. This is something that deserves sustained experimental attention and needs to now investigate blind children in this age group. Ideally an intervention study could be used to teach congenitally blind pre-readers a number of Braille letters using a large pegboard and monitor whether such letters are learnt faster than standard Braille and whether the children can transfer that letter knowledge to standard Braille. It might also be useful to carry out some more qualitative work with blind children trying to access the nature of the information they feel they are able to acquire from a pegboard and how they consider this relates to standard Braille.

In summary, this experiment demonstrated that the children who experienced large tactile Braille initially learnt the Braille letters at a much faster pace than those children learning standard tactile Braille. These same children were then able to directly transfer this knowledge to standard Braille. The data reported here stand in sharp contrast to the data reported in Millar (1977) that appeared to indicate that children showed little ability to transfer knowledge from standard to large Braille. Perhaps the difference between these findings and others, are due to the fact that the enlarged cell in this study was much larger than that of past studies, which typically used a 'jumbo cell' only twice the size of the standard cell. The cell in this study could also be explored interactively since it was similar to a pegboard in nature, as opposed to simply being a pattern of raised dots on paper. A combination of these factors, and the fact that the children were completely lacking in experience of Braille and of reading, may account for why the training had such positive benefits.

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Tables

Task	N	Mean	SD
Large Tactile			
Training	15	4.73	2.02
Testing	14	5.64	1.39
Standard Tactile			
Training	16	2.00	0.89
Testing	15	3.80	1.15
Large Visual			
Training	12	5.92	2.23
Testing	11	3.55	1.21
Small Visual			
Training	11	4.91	2.07
Testing	11	4.27	1.74
General Tactile			
Training	n/a	n/a	n/a
Testing	14	2.29	1.65

Table 1. Descriptive Statistics for Visual and Tactile Tasks across Training and Testing Sessions

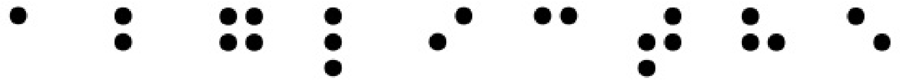

Figure 1.0 The Braille letters used in the study

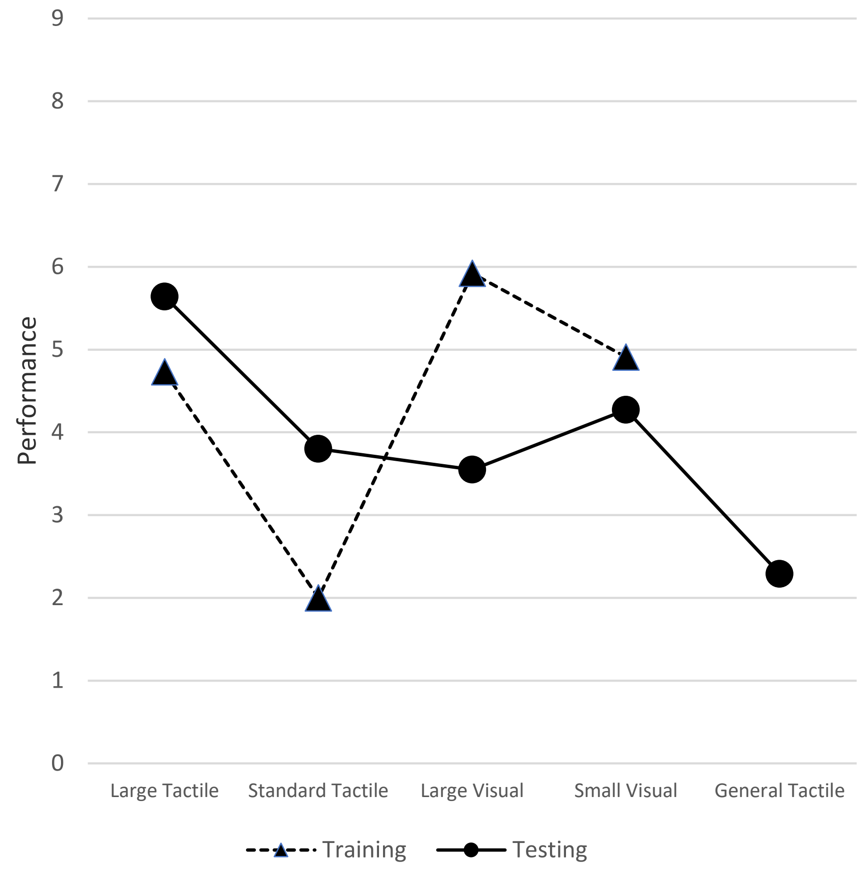

Figure 2.0 Performance across the conditions for the training and testing sessions